REMARKS/ARGUMENTS

Reconsideration of this application is respectfully requested.

Upon entry of the foregoing amendments, claims 1, 4-8, 11-15 and 18-21 are pending in the application with claims 1, 8 and 15 being independent. Claims 1, 4, 8, 11, 15 and 18 are amended. Claims 2, 3, 9, 10, 16 and 17 are canceled without prejudice or disclaimer. These changes are believed to add no new matter, and their entry is respectfully requested.

If the Examiner believes, for any reason, that personal communication will expedite prosecution, the Examiner is invited to telephone the undersigned at the number provided.

Art Rejections

The art rejections spanning pages 2-8 of the Office Action are traversed.

Each of claims 1, 8 and 15 (collectively " the claims") are amended in a substantially equivalent manner to clarify the inventive combination of features of the invention and distinguish same over the references applied against the claims in the Office Action. Specifically, claims 1, 8 and 15 are each amended to include all of the features of its respective dependent claims 2 and 3, 9 and 10, and 16 and 17.

The claims also recite combining into pairs a ***small subset*** of the plurality of sensor signals, taken from the edges of the array. Exemplary support for the terms "small subset" can be found in paragraph [0009] of the present application. The term "small" is relative and, when construed in the context of the claim (and detailed description), means small compared to the total number sensor signals in the plurality of sensor signals forming the main beam. Moreover, one of skill in the art would appreciate that the terms "small subset" mean *not all* of the plurality of signals forming the main beam are paired, but only a *small subset* thereof.

Description of Salient Features of the Claimed Invention

Inherent Characteristics of the Main and Auxiliary Beams in the Claimed Invention and Their Importance to the Operation of the Invention

The clamed invention (i.e., the invention recited in each of claims 1, 8 and 15) forms a main beam having reduced side lobe levels and a small number of "delta-channel auxiliary signals" (also referred to herein as "auxiliary beams"). Specifically, the auxiliary beams are formed by "assigning opposite amplitudes to each signal in the pair to produce delta-channel auxiliary signals having zero response along the maximum response axis." Thus, each auxiliary beam is a simple weighted difference of two sensor signals. Figure A below is an illustration of exemplary main beam and auxiliary beam patterns formed in the manner recited in the claims. One of skill in the art would appreciate that, based on physical principles, the auxiliary beam, formed as a difference of only two sensor signals in the manner claimed, inherently exhibits a relatively flat *non-directional* gain pattern, as depicted in Figure A. That is, the gain pattern is relatively flatter than a gain pattern formed from combining more than only two (i.e., "a pair" of sensor signals as claimed).

The interference suppression method recited in the claims is directed to canceling generally coherent interference signals common to, and therefore correlated between, the main beam and the auxiliary beams. The null of the auxiliary beam of the present invention eliminates a main beam desired signal from the auxiliary beam so that the desired signal is not inadvertently canceled by the suppression method. The relatively non-directional auxiliary beam of the present invention accepts interference signals from *all* directions simultaneously so they can be estimated and canceled. This advantageously avoids complexities in prior art systems discussed below that require highly directional auxiliary beams (instead of relatively non–directional auxiliary beams as claimed), such as fairly complex beam combining to achieve auxiliary beam directionality, and algorithmic ranking of interference power among directional beams to achieve a best sample for cancellation.

In the present invention, estimating interference to be canceled includes using the auxiliary beams (i.e., "delta channel auxiliary signals") themselves to form a co-variance

matrix including "an estimate of the covariance *between two delta-channel auxiliary signals* (i.e., auxiliary beams) . . . [and having a] diagonal containing the variance of the corresponding *delta-channel auxiliary signal*."

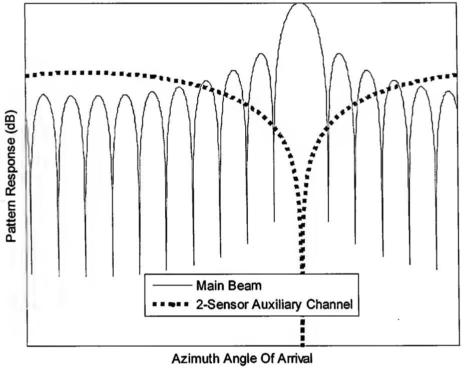

Figure A

The Importance of Forming Auxiliary Beams from Only a "Small Subset" of Signals from Array Edges

The claims each recite forming a main beam from a plurality of sensor signals, which includes applying weights to the signals to reduce sidelobe levels. Exemplary support for this feature can be found at paragraph [0011] in the present application. A well known and ubiquitous approach to reducing sidelobes includes applying weights having tapered magnitudes across the sensor signals. A Hanning window, for example, is a very common weighting function. For a 16-element array, the weights are depicted below in Figure B:

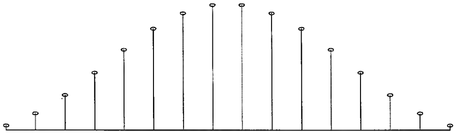

Figure B

Sensor signals from near the center of the array have larger weights, and thus, contribute more to the resulting main beam than do sensor signals from near the edges of the array.

Because some (i.e., a "small subset" as recited in the claims) of the same sensor signals used to form the main beam are also used to form auxiliary beams (i.e., "delta-channel auxiliary signals"), the noise present in the auxiliary beams will be highly correlated with the noise present in the main beam. However, forming the auxiliary beams from only a "small subset" of those signals from near the "edge of the array" as claimed, i.e., using those signals having the smallest tapered weights and thus lowest contribution to the main beam, advantageously reduces the noise level in the auxiliary beams relative to the main beam and correspondingly minimizes the noise *correlation* between the main beam and the auxiliary beams. Therefore, the suppression method of the present invention focuses on undesired

interference signals (which tend to be coherent signals) instead of noise (which tends to be incoherent).

If sensor signals from locations other than the edges of the array were used to form the auxiliary beams as is done in the applied references (prior art – see below), the noise correlation between the main beam and the auxiliary channels would increase relative to that in the claimed invention, and that would cause the suppression method of the invention to try to cancel noise. This could potentially distort the final beam pattern after subtraction.

Applied References

Sekiguchi Does Not Teach or Suggest the Claimed Invention

Sekiguchi teaches an auxiliary multi-beam former (item 7, FIGs. 1 & 6; item 11 FIG. 11), such as an FFT that operates across *all* N elemental sensor signals x(k) to produce N auxiliary beams y(k) that *point in different directions*, i.e., have positive gain directed in different directions. Para. 21, lines 8-9; Para. 28. Then, Sekiguchi's auxiliary beam selection algorithm operates across all of the *directional* beams y(k), and includes, for example, measuring interference power in the beams, and ultimately selecting a number of auxiliary beams equal to a number of interferers to be canceled. Presumably, Sekiguchi's algorithm selects directional auxiliary beams pointing in the direction of the interferers to be canceled in preference to directional auxiliary beams not pointing in the direction of interferers.

Sekiguchi does not teach or suggest many of the features recited in the claims (i.e., each of claims 1, 8 and 15).

First, in contrast to Sekiguchi, which uses all N sensor signals to form N auxiliary beams, the claimed invention combines only a "*small subset*" of the sensor signals into signal pairs to form delta-channel signals, which results in an even smaller number of auxiliary beams, i.e., half of the "small subset" since each delta-channel signal is formed from a *pair* of sensor signals. Also, Sekiguchi does not select a "*small subset of signals from sensors that are adjacently located near the edges of the array*" to form auxiliary beams, as claimed.

As mentioned above, this inventive feature advantageously reduces noise contributions so cancellation focuses on interference instead of the noise.

Second, Sekiguchi uses an additive FFT process for forming *directional* auxiliary beams instead of the claimed *subtractive* process that forms "delta-channel auxiliary signals" which are inherently *non-directional* relative to the directional auxiliary beams required in Sekiguchi. Applicant respectfully submits that the inherently broad beam pattern of the delta-channel auxiliary signal of the present invention, if used in Sekiguchi, would render Sekiguchi's algorithm ineffective because Sekiguchi's algorithm is required to operate across a number of *directional* beams.

Third, the claims also recite a covariance matrix that, in part, forms an estimate between "two *delta-channel* auxiliary signals," and that further includes "estimates of *every possible delta-channel* auxiliary signal combination . . . and contains the variance of the corresponding *delta-channel* auxiliary signal." As mentioned above, Sekiguchi does not use the claimed delta-channels and, therefore, does not teach or suggest *any* of the features of the covariance matrix relating to "delta-channels" recited in the claims.

For at least the many reasons above, Applicant respectfully submits that Sekiguchi is sufficiently different from the invention recited in the claims as to have little or no relevance to the claimed invention.

Drabowitch Does Not Teach or Suggest the Claimed Invention

Drabowitch, at col. 4, lines 10-13, states that, in accordance with his invention:

> . . . the *auxiliary* patterns must be *highly directional.* Under such conditions, each auxiliary antenna pattern will generally only receive a single jammer in its main lobe.

Drabowitch, Fig. 6 is an illustration of highly directional auxiliary beams 19, one of which is aligned with jammer B. One of ordinary skill in the art would appreciate that such highly directional auxiliary beams can only result from combining many sensor signals, i.e., signals from across the full array. This is confirmed in Drabowitch, as described below.

Drabowitch, Fig. 8 is an illustration wherein an array comprises four sub-arrays 20-23 (delivering sensor signals a-d, respectively). Sensor signals from, or across, *all* of the arrays 20-23, *including interior or non-edge* arrays 22 and 23, are combined into auxiliary channels having relatively complex patterns. Use of *all* array signals is necessary to attain the high auxiliary beam directivity required in Drabowitch. At coupler 28, Drabowitch forms complex auxiliary patterns each as a combination of *all* (four) of the different array signals and referred to as a double difference pattern D' = ((a-b)-(c-d)) and a separation pattern E ((a-b)-(c-d)) having highly directional beam patterns depicted in Figs 13 and 12 respectively. Therefore, while Drabowitch does form separate difference signals (e.g., a-b and a-c), such difference signals are *not* themselves used as auxiliary beams for accepting interference. Rather they are used only as intermediate signals that are combined together to form the actual complex directional auxiliary beams/patterns D', E, which specifically point in the directions of interferers. Nowhere does Drabowitch teach or suggest that the component difference signals (a-b, c-d) and the resultant highly directional auxiliary beams (D', E) formed as a combination of these signals can be substituted for each other.

Drabowitch does not teach or suggest the invention recited in the claims (i.e., claims 1, 8 and 15).

First, Drabowitch combines *all* sensor signals a-d across *all* array elements 20-23, including *non-edge* arrays 21 and 22. Thus Drabowitch does not teach or suggest combining only a "*small subset*" of the sensor signals into signal pairs, wherein the small subset of the plurality of sensor signal that are combined into signal pairs comprise signals from sensors that are *adjacently located near the edges of the array*, as recited in the claims.

Second, Drabowitch forms auxiliary beams D', E as a complex combination of multiple difference signals to achieve highly directional beams. Drabowitch does not teach or suggest assigning opposite amplitudes to each signal in *the pair* (of sensor signals) to produce a delta-channel auxiliary signal (i.e., auxiliary beam), as recited in the claims. As claimed, each delta-channel auxiliary signal or beam is simply a weighted difference between two sensor signals, not a combination of multiple difference signals as in Drabowitch . As mentioned above, and as would be appreciated by one of skill in the art, the approach of the claimed invention results in an inherently relatively *non-directional* auxiliary beam which is

inconsistent with the highly directional requirement of Drabowitch (see inherently non-directional auxiliary beam depicted in Fig. A above as compared against highly directional Drabowitch auxiliary beams in Figs. 12 (E) and 13 (D')). For all of these reasons, the auxiliary beams in Drabowitch (D', E) do not equate to the delta-channel signals recited in the claims.

Third, regarding a covariance matrix, Drabowitch states that "if the auxiliary arrays are *sufficiently directional* . . . the *covariance matrix* is usually diagonal dominated." Drabowitch, col. 7, lines 11-15. This suggests to one of skill in the art that the covariance matrix of Drabowitch includes estimates of covariance between Drabowitch's *highly directional* complex auxiliary beams, e.g., D', E, *not* estimates of covariance between each of the component difference signals a-c and c-d making up the highly directional beams and which are, by themselves, relatively non-directional and are not used as auxiliary beams for accepting interference. The component difference signals (a-b, c-d) and the resultant highly directional auxiliary beams (D', E) are not interchangeable. Therefore, Drabowitch does not teach or suggest the claimed co-variance matrix which includes "an estimate of the covariance *between two delta-channel auxiliary signals*," and further a "main diagonal" which "contains the *variance of the corresponding delta-channel auxiliary signal*."

Sekiguchi and Drabowitch in Combination Do Not Teach or Suggest the Claimed Invention

Sekiguchi and Drabowitch in combination do not teach or suggest the invention recited in each of claims 1, 8 and 15. Neither reference teaches or suggests the advantageous feature of combining only "a <u>*small*</u> *subset* of the <u>plurality of</u> sensor signals into signal pairs<u>, wherein the small subset of the plurality of sensor signal that are combined into signal pairs comprise signals from sensors that are *adjacently located near the edges of the array*</u>, as recited in the claims. In fact, both references explicitly teach forming auxiliary beams based on *all* of the sensor signals, which teaches away from the present invention.

Neither reference teaches or suggests forming relatively non-directional auxiliary beams for sampling interference as a simple difference between a pair of sensor signals as

recited in the claims, namely, by "assigning opposite amplitudes to each signal in the pair to produce delta-channel auxiliary signals having zero response along the maximum response axis."

Neither reference teaches or suggest the claimed covariance matrix that, for example, estimates covariance between "two delta-channel auxiliary signals."

Substituting the directional auxiliary beams D', E of Drabowitch into Sekiguchi and creating a covariance matrix in Sekiguchi based on the Drabowitch auxiliary beams D', E does not construct the claimed covariance matrix as recited in the claims, for the reasons advanced above in connection with Drabowitch.

The method of canceling interference described in Sekiguchi would fail if the auxiliary beams D', E described in Drabowitch were used (i.e., substituted) in Sekiguchi, i.e., if Skiguchi's auxiliary beams y(k) were substituted with Drabowitch's auxiliary beams D', E. With reference to Figure C below, Sekguchi's N simultaneous auxiliary beams y(k) (e.g., as depicted in solid line in Figure C, wherein two of the N auxiliary beams y(k) are depicted) sample interference signals to be canceled. The method of Sekiguchi (paragraph 48, 49 and 55) specifically searches auxiliary beams y(k) for maximum interference signal power and ranks the beams in order by that power. But, according to Drabowitch, each of the auxiliary beams D', E has a center null aligned with a maximum radiation receive direction. See, e.g., Figures 12 and 13 of Drabowitch. Thus, if auxiliary beams D', E were substituted for each of Sekiguchi's auxiliary beams y(k) (which would be the case in a combination of Sekiguchi and Drabowitch as indicated in the Office Action claim rejection rationale), the nulls of Drabowitch's auxiliary beams D', E would tend to align directly with or slightly offset from interference signals that would have otherwise been detected by full lobes of the Sekiguchi auxiliary beams y(k) (now substituted by beams D' E), which don't exhibit Drabowitch's nulls. In this case, Sekiguchi's ranking of substituted beams y(k) (now beams D', E) based on received interference power would be different from, and incorrect compared to, the ranking without the substitution, which would lead to unpredictable results. No technical rationale is provided in Sekiguchi (or Drabowitch) regarding how auxiliary beams exhibiting central nulls formed by a subtractive process, as in Drabowitch, could be used or made compatible with the interference canceling algorithm of Sekiguchi, which is squarely based

on auxiliary beams formed as a result of an additive process, e.g., FFT, that do not exhibit such central nulls. This technical incompatibility between Sekiguchi and Drabowitch teaches away from combining the two references as suggested in the Office Action to construct the claimed invention. Therefore, one of ordinary skill would not have been motivated to combine Sekiguchi with Drabowitch in order to reconstruct the invention as claimed.

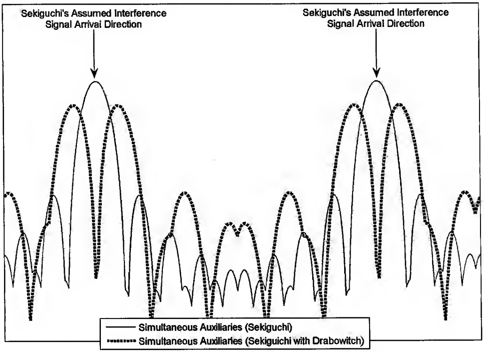

Figure C

The canceling methods of both Sekiguchi and Drabowitch not only teach but actually require relatively *highly directed* auxiliary beams in order to operate properly. The claimed invention utilizes inherently relatively *non-directional* auxiliary beams, as would be appreciated by one of skill in the art. Therefore, Applicant respectfully submits that Sekiguchi and Drabowitch reinforce each other in teaching away from the present invention, are substantially irrelevant to the present invention and, therefore, one of ordinary skill in the art would not have looked to either Sekiguchi or Drabowitch to construct the invention as claimed.

For at least all of the reasons advanced above, the invention recited in each of claims 1, 8 and 15 is patentable over the applied references alone or in combination.

All of the dependent claims are patentable for at least the same reasons the claims from which they respectively depend are patentable.

Conclusion

On the basis of the above amendments and remarks, reconsideration and allowance of this application are believed warranted.

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